

Duplex Color Doppler Evaluation of Intrarenal Resistive Index in Type 2 Diabetic Patients Having Diabetic Nephropathy

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Diabetic nephropathy (DN) is considered the most frequent cause of end-stage renal disease (ESRD). For early diagnosis and follow up of renal function in patient with established DN, Duplex Doppler Sonography can be used as noninvasive tool. The aim and objective of the study was to determine whether resistive index could remain higher in type 2 diabetic patients having nephropathy in comparison with that of non-diabetic controls. This case-control study was done in the department of Radiology and Imaging, Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM) from 1st July 2014 to 30th June 2015. Total 65 diabetic nephropathy patients were taken as study group and 65 healthy subjects were included as healthy control subjects. Duplex Color Doppler sonography of interlobar artery was carried out in both groups for the measurement of Peak systolic velocity, end diastolic velocity and arterial Resistive Index (RI). The RI of interlobar artery of left kidney in control group was 0.58 ± 0.08 (mean \pm SD) and the mean RI of interlobar artery of left kidney in diabetic nephropathy patients was 0.74 ± 0.53 (mean \pm SD). The difference of RI of interlobar artery of left kidney in the two groups was statistically significant and the RI of right kidney of control and that of case groups were 0.60 ± 0.09 and 0.76 ± 0.031 (mean \pm SD) respectively. In between control and case groups the RI of right kidney was statistically significant ($p = <0.5$). So, resistive index of interlobar artery was increased in type 2 diabetic nephropathy patients in comparison to control group. Study findings reveal that resistive index remains significantly higher in patients with diabetic nephropathy than control group. For this reason, RI can be used for early diagnosis of diabetic nephropathy by Duplex Doppler ultrasonography.

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Key words: Duplex color doppler, Resistive index, Diabetic nephropathy

Introduction

Diabetic nephropathy (DN) is a type of progressive kidney disease with the prevalence is 20 to 40 percent¹. In Africa and other developing countries, DN is considered the most frequent cause of end-stage renal disease (ESRD)^{2,3}. The incidence of end-stage renal disease (ESRD) and type 2 DM as a co-morbid condition has increased continuously during the past decades^{4,5}. Presently, there is greater focus on early detection of nephropathy which helps to the better outcomes of the patients⁶. In diabetic patients Duplex Doppler Sonography can be used as noninvasive tool for early diagnosis of diabetic nephropathy and for the follow up of renal function in established diabetic nephropathy⁷. Available since 1980s, color doppler duplex sonography has allowed evaluation of alterations of renal perfusions non-invasively by interrogating intrarenal arteries or showing general renal perfusions⁸. Among parameters measured by Doppler Ultrasonography, resistance index (RI) value has been most frequently used in clinical practice⁹. In diabetic nephropathy changes occur

in the compliance of the vessels, resistance of the vessels which affects the resistive index.

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Hence, renal Doppler can be used to detect the early changes in blood flow and they reflect the progression of diabetic nephropathy¹⁰. But intra renal venous impedance index does not offer a significant advantage over arterial resistive index¹¹. In this study we have focused on resistive index value of interlobar arteries of kidney and tried to determine whether resistive index could remain higher in type 2 diabetic patients having nephropathy in comparison with that of non-diabetic controls.

Methods

This case-control study was attempted on 130 subjects aged 33-70 years in the department of Radiology and Imaging, BIRDEM from 1st July 2014 to 30th June 2015, out of them 65 type 2 diabetic patients with nephropathy were consider study group and 65 healthy adult subjects were considered as control group. Among them 74 patients in preliminary selection, nine diabetic patients with nephropathy were excluded. Five patients were excluded as they had uncontrolled high blood pressure, four more patients were also excluded, as they refuse to take part in the study.

Demographic information was prospectively recorded and substantiated by means of inspection of medical record, Information included the subject's age, sex, medical and surgical history, clinical history of diabetes, followed by Duplex color Doppler study with spectral analysis. The color Doppler study was performed first by the investigator himself and subsequently confirmed by a radiologist of the department of Radiology and Imaging, BIRDEM, who did not know the subject's condition to eliminate bias. Duplex Color sonography of interlobar arteries was carried out in both groups to measure the peak systolic velocity, the end diastolic velocity and resistive index.

Operational definition

Resistive index

The resistive index (RI) is a popular parameter for characterizing the arterial waveform at Doppler ultrasonography (US). The RI is defined as $(S-D)/S$, where S is the height of the systolic peak and D is the height of the end diastolic peak (Pourcelot 1974). Normal ranges of resistive index values vary from 0.58 to 0.68 in normal kidney¹². The renal resistive index reflects intrarenal vascular resistance^{8,13}.

Diabetic nephropathy

Diabetic nephropathy is a clinical syndrome characterized by the following: Persistent albuminuria (>300 mg/d or >200 $\mu\text{g}/\text{min}$) that is confirmed on at least 2 occasions 3-6 months apart; Progressive decline in the glomerular filtration rate (GFR); Elevated arterial blood pressure.

Statistical analysis

Result of the study was calculated and analyzed by standard statistical method and was presented in forms of tables and graphs. Data were expressed as mean \pm SD. A value of $p<0.05$ was considered statistically significant. Independent sample 't' test and paired 't' tests were used to compare the peak systolic velocity, End diastolic velocity and Resistive index between case and control and between right and left kidney of the same respondents respectively. The data were analyzed with the SPSS for Windows (IBM SPSS Statistics for Windows, version 17.0, Armonk, NY:IBM Corp.) software.

Results

The mean age of the control subjects was 51.31 ± 7.79 years. The mean age of case group was 52.88 years with standard deviation (SD) ± 8.96 years and their ranged from 33 to 70 in case group. Maximum numbers were found in the age group of 41-50 years.

Out of which 44(68.0%) were male and rest 21(32.0%) were female in control group and Out of which 38(58.0%) were male and rest 27(42.0%) were female patients in case group.

The mean peak systolic velocity of interlobar artery of right kidney of normal control subjects was 23.99 ± 5.24 (mean \pm SD), ranged 16.6-32.2 and the mean peak systolic velocity of interlobar artery of left kidney was 21.22 ± 2.12 (mean \pm SD), ranged 15.9-27.1. There was no statistically significant ($p>0.05$) difference of mean peak systolic velocity of interlobar artery in right and left kidneys of normal control subjects.

The mean peak systolic velocity of interlobar artery of type 2 diabetic patients with nephropathy in right kidney was 27.674 ± 17.0676 (mean \pm SD), ranged 15.2-74.0 and the mean peak systolic velocity of interlobar artery of left kidney was 29.951 ± 18.2794 (mean \pm SD), ranged 12.9-74.1. There was no statistically significant ($p>0.05$) difference of mean peak systolic velocity

of interlobar artery in right and left kidneys type 2 diabetic patients with nephropathy (Table I).

Table I: Comparison between peak systolic velocity of right and left kidneys of diabetic nephropathy patients (n=65)

Peak systolic velocity	Mean±SD	Range	't' value	p value
Right kidney (n=65)	27.674±17.0676	15.2-74.0	-1.001	0.321
Left kidney(n=65)	29.951±18.2794	12.9-74.1		

The mean end diastolic velocity of interlobar artery of control subjects in right kidney was 10.485±2.3448 (mean±SD) ranged 5.3-13.8 and the mean end diastolic velocity of interlobar artery of control subjects in left kidney was 8.889±1.3832 (mean±SD), ranged 7.2-11.5. There was no statistically significant (p>0.05) difference of mean end diastolic velocity of interlobar artery in right and left kidneys of normal control subjects.

The mean end diastolic velocity of interlobar artery of type 2 diabetic patients with nephropathy in right kidney was 7.435±4.5590 (mean±SD) ranged 3.8-19.0 and the mean end diastolic velocity of interlobar artery of cases in left kidney was 7.668±4.0182 (mean±SD) and ranged 4.1-19.0. There was no statistically significant (p>0.05) difference of mean end diastolic velocity of interlobar artery in right and left kidneys of diabetic nephropathy patient group (Table II).

Table II: Comparison between end diastolic velocity of right and left kidneys of diabetic nephropathy patients (n=65)

End diastolic velocity	Mean±SD	Range	't' value	p value
Right kidney (n=65)	7.435±4.5590	3.8-19.0	-3.737	0.110
Left kidney (n=65)	7.668±4.0182	4.1-19.0		

The mean resistive index (RI) of interlobar artery in right kidney of control subjects was 0.60±0.09 (mean±SD), ranged 0.37-0.72 and the mean resistive index (RI) of interlobar artery in left kidney was 0.58±0.08 (mean±SD), ranged 0.35-0.69. There was no statistically significant (p>0.05) difference of mean resistive index (RI) of interlobar artery was found in right and left kidneys of normal control subjects.

The mean resistive index (RI) of interlobar artery in right kidney was 0.76±0.031 (mean±SD), ranged 0.72-0.84 and the mean resistive index (RI) of interlobar artery in left kidney was 0.74±0.53 (mean±SD) and ranged 0.62-0.84. There was no statistically significant (p>0.05) difference of mean resistive index (RI) of interlobar artery was found in right and left kidneys of diabetic nephropathy patients (Table III).

Table III: Comparison between resistive index (RI) of interlobar artery of right and left kidneys of diabetic nephropathy patients (n=65)

Resistive index	Mean±SD	Range	't' value	p value
Right kidney (n=65)	0.76±.031	0.72-0.84	1.477	0.145
Left kidney (n=65)	0.74±0.53	0.62-0.84		

The mean peak systolic velocity of right kidney in control group was 23.99±5.24 (mean±SD), ranged 16.2-75.0 and the mean peak systolic velocity in diabetic nephropathy patients was 28.87±5.24 (mean±SD) and ranged 16.6-32.2. The mean difference of peak systolic velocity of right kidney in the two groups were statistically significant (p<0.05).

Original Contribution

The mean peak systolic velocity of left kidney in control group was 21.52 ± 3.12 (mean \pm SD), ranged 16.9-26.1 and the mean peak systolic velocity in diabetic nephropathy patients was 29.95 ± 18.28 (mean \pm SD), ranged 9.9-75.0. The mean difference of peak systolic velocity of left kidney in the two groups were statistically highly significant ($p<0.001$) (Table IV).

Table IV: Comparison between peak systolic velocity of left kidney between case and control groups (n=130)

Peak systolic velocity of left kidney	Mean \pm SD	Range	't' value	p value
Control group (n=65)	21.52 ± 3.12	16.9-26.1	3.665	<0.001
Case group (n=65)	29.95 ± 18.28	9.9-75.0		

The mean end diastolic velocity of right kidney in control group was 9.38 ± 2.25 (mean \pm SD), ranged 5.7-13.7 and the mean end diastolic velocity of right kidney in diabetic nephropathy patients was 7.04 ± 4.56 (mean \pm SD), ranged 3.8-19.0. The mean difference of end diastolic velocity of right kidney in the two groups was statistically highly significant ($p<0.001$) (Table V).

Table V: Comparison of end diastolic velocity of right kidney between case and control groups (n=130)

End diastolic velocity of right kidney	Mean \pm SD	Range	't' value	p value
Control group (n=65)	9.38 ± 2.25	5.7-13.7	-3.727	<0.001
Case group (n=65)	7.04 ± 4.56	3.8-19.0		

The mean resistive index (RI) of interlobar artery of right kidney in control group was 0.60 ± 0.09 (mean \pm SD), ranged 0.37-0.72 and the mean resistive index (RI) of interlobar artery of right kidney in diabetic nephropathy patients was 0.76 ± 0.031 (mean \pm SD), ranged 0.72-0.84. The mean difference of resistive index (RI) of interlobar artery of right kidney in the two groups was statistically highly significant ($p<0.001$) shown in Table VI.

Table VI: Comparison of resistive index (RI) of interlobar artery of right kidney between case and control groups (n=130)

Resistive index of right kidney	Mean \pm SD	Range	't' value	p value
Control group (n=65)	0.60 ± 0.09	0.37-0.72	13.735	<0.001
Case group (n=65)	0.76 ± 0.031	0.72-0.84		

Discussion

The study was conducted to observe the difference between values of intrarenal resistive index measured by duplex color Doppler US in type 2 diabetic patients having diabetic nephropathy and in healthy adult control subjects. For this purpose, 65 diabetic nephropathy patients were taken as study group and 65 healthy subjects were included as healthy control subjects. Duplex Color Doppler sonography of interlobar artery was carried out in both groups to measure the Peak systolic velocity and End diastolic velocity and Resistive Index (RI). The mean age of the control subjects was 51.31 ± 7.89 years and that of the case was

52.7 ± 6.96 years. In control group 44(68.0%) were male and 21(32.0%) were female where as in case group 38(58.0%) were male and rest 27(42.0%) were female patients. In case group the mean duration of DM was 12.78 ± 4.01 years. Maximum patients were suffering from diabetes mellitus for 12-15 years. In this study, it was found that mean peak systolic velocity and mean end diastolic velocity right kidney of 65 healthy adult control subjects were 23.99 ± 5.24 (mean \pm SD) ranged 16.2-32.2 and 9.38 ± 2.25 (mean \pm SD) ranged 5.7-13.7 respectively and that of 65 diabetic patients with nephropathy were 28.874 ± 17.06 (mean \pm SD) ranging from 16.6-75.0 and 7.435 ± 4.5590

(mean±SD) ranged 3.8-19. Therefore it reveals that in between case and control mean peak systolic velocity and mean end diastolic velocity of right kidneys were statistically highly significant ($p<0.001$). This findings is consistent with the other study findings^{7,14}. In the present study, it was also found that the mean peak systolic velocity and mean end diastolic velocity of left kidney of 65 healthy subjects were 21.52 ± 3.12 (mean±SD) ranged 16.9-26.1 and 8.889 ± 1.3832 (mean±SD) ranged 7.2-11.5 respectively. And the mean peak systolic velocity and end diastolic velocity of left kidney of 65 diabetic patients with nephropathy were 29.95 ± 18.27 (mean±SD) ranged 12.9-74.0 and 7.668 ± 4.0182 (mean±SD) ranged 4.1-19.0. Therefore it was proved that mean peak systolic velocity of left kidney in between case and control groups were statistically highly significant ($p<0.001$) and mean end diastolic velocity of left kidneys in between two groups were statistically significant ($p<0.05$). Other studies^{7,14} were reported similar findings as well. In this study the mean resistive index of right kidneys of control was 0.60 ± 0.09 (mean±SD) ranged 0.37-0.72 and that of 0.76 ± 0.031 (mean±SD) ranged 0.72-0.84 in case groups of right kidneys were statistically highly significant ($p<0.001$) in unpaired 't' test. The study revealed that mean resistive index of left kidneys of control and that of left kidneys of case were 0.58 ± 0.08 (mean±SD) ranged 0.35-0.69 and 0.74 ± 0.53 (mean±SD) ranged 0.62-0.84 respectively and in between two groups mean difference of resistive index of left kidneys were statistically significant ($p<0.05$). These findings were consistent with the other study findings^{7,15,16,17,18}. So, the resistive index of interlobar artery was increased in type 2 diabetic patients with nephropathy group compared to control group.

Conclusion

Doppler ultrasonography adds extra dimension in the sonographic assessment of renal dysfunction. It can be concluded in present study that resistive index remains significantly higher in patients with diabetic nephropathy than in controls. Thus Duplex Doppler ultrasonography allows the rapid, noninvasive evaluation of the intrarenal vasculature and can be used as an easily available parameter of the evolution and a predictor in patients with clinical diabetic nephropathy.

Recommendations

Duplex color Doppler sonography is a relatively cheap, available, painless and non-hazardous imaging tool. However, further study can be undertaken by including large number of study subjects, comparing haemodynamic changes in different stages of diabetic nephropathy, finding out the correlation of haemodynamic changes and levels of glycaemic control.

References

1. Diabetic Nephropathy (Kidney Disease) (2012) NY: University of Rochester Medical Center, Rochester. Available at: <http://www.iinn.rochester.edu/encyclopedia/content>.
2. Locatelli F, Canaud B, Eckardt KU, Zoccali C et al. The importance of diabetic nephropathy in current nephrological practice. *Nephrol Dial Transplant*. 2003;18:1716-25.
3. Islam SMA. Association between Diabetic Nephropathy and Hypertension among Patients Admitted in A Tertiary Hospital in Dhaka. Bangladesh. 2012. Available from: <http://ghf.globalhealthforum.net/2011/12/15/a-ssociation-between-diabetic-nephropathy-and-hypertension-among-patients-admitted-in-a-tertiary-hospital-in-Dhaka-Banaladesh/>.
4. Ritz E, Stefanski A. Diabetic nephropathy in type 2 diabetes. *Am J Kidney Dis*. 1996;27:167-94.
5. Ritz E, Orth SR. Nephropathy in patients with type 2 diabetes mellitus. *N Engl J Med*. 1999;341:1127-33.
6. Puttemans T, Nemry C.) Diabetes: the use of color Doppler sonography for the assessment of vascular complications. *European Journal of Ultrasound*. 1998;7:15-22.
7. Akeel AM, Zwain S, Ali K. Intrarenal haemodynamic changes in type 2 diabetic patients. *Kufa Med Journal*. 2010;13:1.
8. Reinitz ER, Goldman MH, Sais J. Evaluation of transplant arterial flow by Doppler sound-spectral analysis. *Arch Surg*. 1983;118:415-9.
9. Milovanceva-Popovska M, Dzikova S. Progression of diabetic nephropathy: value of intrarenal resistive index (RI). *Sec Biol Med Sci MASA*. 2007;XXVIII (1):69-79.
10. Tushar PR, Tushar BP, Rajashree, Yogendra VB et al. Clinical profile of diabetic nephropathy and correlation with intrarenal resistivity index by duplex ultasonography. *World J Nephrol Urol*. 2012;1(4-5):107-14.

11. Seok HJ, Dae CJ, Sun HK, Seung HK. Renal venous doppler ultrasonography in normal subjects and patients with diabetic nephropathy: Value of venous impedance index measurements. *Journal of Clinical Ultrasound*. 2011;517-20.
12. Milovanceva-Popovska M, Dzikova S. The value of intrarenal resistive index in Diabetic nephropathy. *Bantao Journal*. 2009;7(1):38-44.
13. Platt JF, Ellis JH, Rubin JM, Sedman AB. Intrarenal arterial Doppler sonography in patients with non-obstructive renal disease: correlation of resistive index with biopsy findings. *AJR*. 1990;154:223-7.
14. Spomenka LJ, Boris BR, Ivana PA. Renal resistance index in type 2 diabetes. *Diabetologia Croatica*. 2006;35(1):1-35.
15. Kim SH, Kim SM, Lee HK, Kim S, Lee JS, Han MC et al. Diabetic nephropathy: duplex Doppler ultrasound findings. *Diabetes Res Clin Pract*. 1992;18(2):75-81.
16. Ishimura E, Wa YN, Kawagishi T, Morii H. Intrarenal hemodynamic abnormalities in diabetic nephropathy measured by duplex Doppler sonography. *Kidney International*. 1997;51(6):1920-7.
17. Sari A, Dinc H, Zibandeh A, Gümele HR. Value of resistive index in patients with clinical diabetic nephropathy. *Invest Radiol*. 1999;14(1):201-9.
18. Nejad MN, Jafari B, Alipour P. Arterial Resistive Index (RI) in Type II Diabetic Nephropathy Stages and Healthy Controls. *Iran J Radiol*. 2009;6(1):29-32.